Response of Bighorn Sheep to Restoration of Winter Range: Revisited

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Abstract: Winter range for bighorn sheep (*Ovis canadensis*) in south-eastern British Columbia has declined in both quality and availability due to forest ingrowth. In 2003 we applied mechanical treatments to a 200 ha portion of traditional bighorn winter range near Radium Hot Springs, British Columbia in an attempt to improve habitat suitability. In 2005 we applied prescribed fire to a portion of the previously treated area. We monitored bighorn sheep response to these treatments by deploying GPS radio collars on 10 sheep each year from 2002 to 2007 and collecting daily location points for each animal. Study animals increased their use of the treated area from 1.0% of daily locations in 2002 to 8.9% in 2004 and 4.3% in 2007. We plan to apply additional mechanical treatments and prescribed burning to nearby areas of winter range and mid-elevation transitional range, and to continue to monitor bighorn sheep response.

Key words: bighorn sheep, British Columbia, GPS, habitat, Kootenay National Park, *Ovis canadensis*, prescribed fire, radiotelemetry, restoration, winter range.

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In winter, most populations of bighorn sheep (*Ovis canadensis*) in southeastern British Columbia depend on low-elevation open forest and grassland habitats that were formerly maintained by frequent, low-intensity ground fires (Demarchi et al. 2000) or by mixed fire regimes of frequent low-intensity fires with occasional stand-replacing fires (Gayton 2001). Fire suppression has altered the natural disturbance regime and these habitats have declined due to the resultant forest encroachment (Davidson 1994). Additionally, the quality, extent and effectiveness of critical winter range have been affected by competing land uses, including urban and rural settlement, agriculture, resource extraction, and off-road motorized recreation (Demarchi et al. 2000; Tremblay 2001; Tremblay and Dibb 2004). At Radium Hot Springs, British Columbia the bighorn sheep population consists of about 200 animals (Dibb 2006). In the last several decades, deteriorating range conditions on traditional winter habitats of this herd have been implicated in the partial abandonment of these ranges in favour of artificial grasslands such as golf courses, residential lawns and highway rights-of-way within and adjacent to the town (Tremblay and Dibb 2004). This has increased habituation of bighorns, exposed them to harassment by dogs and humans, and increased mortality of bighorns along highways. Consequently, Tremblay (2001) recommended restoration of portions of historic bighorn winter range in the Radium Hot Springs area.

We carried out mechanical treatments on a 200 ha site in 2003, including timber

removal with retention of clumps of veteran trees, brushing, piling and burning, and noxious weed control. We began global positioning system (GPS) radiotelemetry monitoring of a sample of bighorn sheep in January 2002 and therefore acquired one full year of pre-treatment data. We previously reported on the response of the Radium bighorn sheep to restoration treatments as indicated by telemetry results from 2002 through 2004 (Dibb and Quinn 2006). Since that time we have completed a prescribed fire within the previously treated restoration area, and have continued to monitor bighorn sheep response. The purpose of this paper is to provide an update on sheep response including the period of 2005 through 2007.

Methods

Radiotelemetry monitoring methods were the same as those reported in Dibb and Quinn (2006). The Parks Canada Agency Animal Care Committee approved animal capture and handling methods under Research and Collection Permits LLYK02-01, LLYK02-35, LLYK03-15, LLYK04-02, and KOONP-2005-3518.

For each study animal we selected one GPS location per day, and then used a Geographic Information System (GIS) to determine which locations were inside the perimeter of the 2003 restoration area and which were outside. We determined the average number of locations inside the restoration area per animal per year, and also determined the total number of points inside and outside the restoration area in each year with all study animal locations pooled. We conducted chi-square analyses on the pooled animal locations to assess the magnitude and significance of between-year differences. We also summarized animal use of the restoration area by month and by sex.

We carried out a low intensity prescribed fire on 21 and 22 April 2005 by deploying ground crews with drip torches. The burn covered approximately 110 ha of the 200 ha area previously treated using mechanical means (Figure 1). Burning days were chosen according to a suite of weather and soil moisture parameters such that the predicted fire intensity would be sufficient to achieve objectives of burning slash, surface litter and duff while not causing widespread mortality of desirable native bunchgrasses. No mechanical treatment took place after 2003. We assessed bighorn sheep response to burns by considering use levels of the restoration area in pre-burn years compared to post-burn years. In addition, we examined all sheep locations within the original 2003 restoration boundaries in 2 periods: 2003-2004 (pre-burn) and 2006-2007 (post-burn), and determined the proportion of locations within the burned zone of the restoration area versus the unburned zones of the restoration area. We then used a chi-square analysis to assess the significance of differences of pre-burn and post-burn use of the burned and unburned areas.

Results

Bighorn sheep made more use of the restoration areas in each of the post-treatment years (2003 through 2007) than they did during the pre-treatment year (2002) (Figure 2). Differences in use levels, assessed by comparing each post-treatment year to 2002, were all significant to $P < 0.001$, except for 2006 (Table 1). Highest use levels were in 2004 and 2005, and lowest use levels were in 2006.

Most use of the restoration area occurred in March through June, prior to the sheep migrating to their lambing or summer ranges, and in October, when the sheep were moving between summer and rutting ranges (Figure 3). Female use declined rapidly after the middle of May because nearly all

females migrated to lambing range at high elevation between mid- and late May. Male use levels were relatively high in June, but declined to near zero in July after the males moved to their summer ranges. Most sheep use of the restoration area in October was by males. Use levels by both sexes were low in November through February.

The increased use of the restoration area was distributed among nearly all study animals in the post-treatment years (Table 1). In 2002, prior to treatment, 5 of 7 animals were recorded on at least 1 day within the boundaries of the restoration sites (range = 1-5, SD = 1.5) for an average of 2.4 days per animal. In the post-treatment years, 2003-2007, 41 of 43 animals were recorded within the restoration area on at least one day (range = 1 - 56, SD = 13.1) for an average of 10.4 days per animal.

Subsequent to the initial treatments, the lowest levels of sheep use occurred in 2006 and 2007, the years immediately following the 2005 prescribed fire. In 2003 and 2004, 20.8% of locations inside the treatment area occurred within the perimeter of the future prescribed burn area. In 2006 and 2007, only 7.0% of locations inside the treatment area occurred within the burn perimeter, a significant difference compared to the pre-burn years ($\chi^2 = 10.8$, P = 0.001).

Discussion

Although use levels in all post-treatment years were higher than in 2002, the pattern of rapidly increasing sheep use from 2002 to 2004, as reported by Dibb and Quinn (2006), did not continue in subsequent years. However, we do not believe that the decline in sheep use after 2005 can be attributed to vegetation change within the restoration area. Page (2006) monitored a suite of indicator plants in the restoration area over the period of 2004 through 2006 and reported that forage plants generally increased in cover over the period of her study (only non-native species failed to increase). The same study also monitored plant responses on burned versus unburned sites. These results showed that most forage plants increased their cover on both burned and unburned sites. For non-native plants, cover decreased in unburned sites but increased in burned sites, although these differences were not statistically significant at the P = 0.1 level. The increase in percent cover of non-native species was from approximately 3% (2004) to 7% (2006), however we do not expect that these differences would have resulted in an observable decline in bighorn sheep use of the burned sites. We are not aware of vegetation changes at the shrub or overstory level that would have influenced bighorn sheep habitat selection.

Human activity has generally increased in the Radium Hot Springs area in recent years, with rapid growth in the human population (British Columbia Stats 2006) and strong demand for recreational opportunities. Human activity levels in the restoration area are of concern, but at present no on-going monitoring is occurring, and we have no evidence that recreational use of the area is limiting sheep use. Future monitoring of the patterns of human use within and near the restoration area would be valuable in helping us to understand the potential impacts of human activity.

Although sheep appeared to avoid the restoration area during the months with highest average snow depths (December through February), preliminary investigation showed no apparent relationship between sheep use and either winter snow depth or the date of disappearance of the winter snow pack. For example, snow disappeared from the restoration area relatively early in 2006, but sheep use levels were lower than in other years. Sheep use did not appear to be closely related to plant phenology in the

restoration area. Much of the use in March and April occurred prior to plant green-up, even though green-up occurred earlier within the nearby winter ranges at slightly lower elevation.

We speculate that sheep may have adjusted their use of the restoration area in response to the presence of predators, particularly cougars (*Puma concolor*). The low levels of use of the restoration area in March through April of 2006 coincided with a period in which at least one cougar was known to be active, one of the few periods during our study in which repeat sightings of cougar were made (Parks Canada, unpublished data). Harassment by humans and dogs, either within the restoration area or in the Village of Radium Hot Springs, may have influenced sheep behaviour. It is also likely that arbitrary movement and habitat selection decisions by dominant animals played out differently in different years, contributing to the changing patterns of sheep use observed through our study.

Our monitoring confirmed the seasonal pattern of sheep use of the restoration area reported by Dibb and Quinn (2006). Most post-treatment use of the restoration area by Radium bighorn sheep occurred in October, and in March through June, periods when, prior to treatment, the sheep were still on winter range elsewhere in the Radium area. This may have alleviated some grazing pressure on winter range, as well as slightly reduced the various risks the sheep take in living near highways and within the village of Radium Hot Springs. However, this restoration site appears not to have the inherent capability to serve as core winter range for bighorn sheep, primarily due to its flatness and the resultant winter snow retention. The Parks Canada Agency currently has prescribed burn plans for the southwest and west facing slopes of Redstreak Mountain above the restoration area. This site, pending removal of thick forest cover through burning, appears to have a potentially suitable combination of habitat, slope, aspect, interspersion of escape terrain, and proximity to occupied sheep habitat. We plan to continue to monitor bighorn sheep response to these prescribed fire and other treatments in order to assess effectiveness, to adapt future treatments on the basis of this new knowledge, and to develop bighorn sheep habitat restoration prescriptions with broad applicability throughout bighorn sheep range in southeastern British Columbia. Our results demonstrate the value of long term monitoring, since some patterns of sheep response were not observable within the first 2 or 3 years of post-treatment monitoring.

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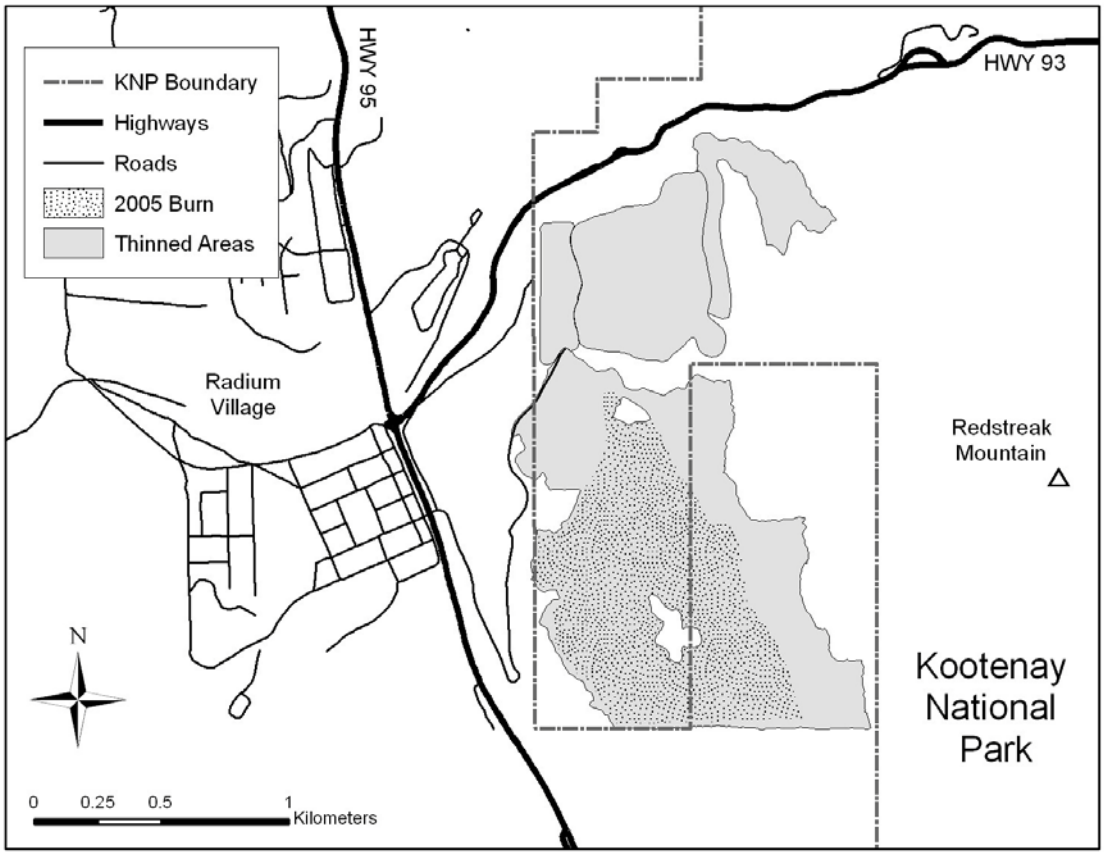

Figure 1. Layout of Redstreak restoration area in relation to the village of Radium Hot Springs and Kootenay National Park.

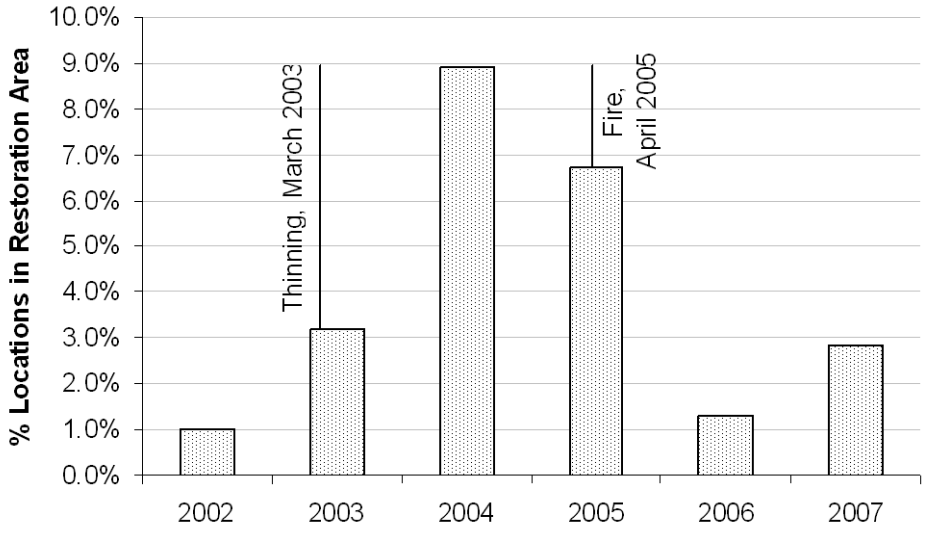

Figure 2. Percentage of bighorn sheep daily locations in restoration area by year, 2002 – 2007.

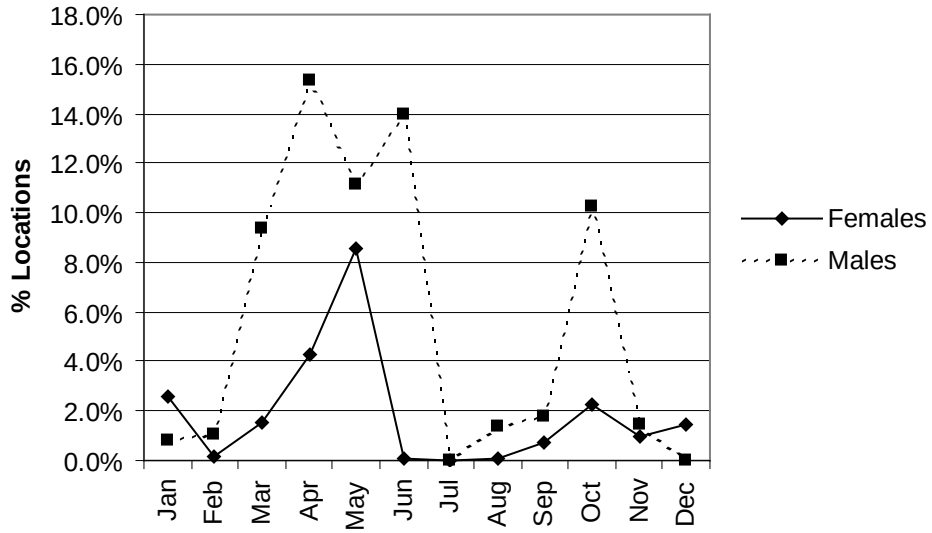

Figure 3. Percentage of bighorn sheep daily locations in restoration area by month, 2002 –2007.

Year	# Study Animals*	# Animals with ≥ 1 Location Inside	Average # Locations Inside Per Animal	Total # Locations (all animals)	% Total Locations Inside	□□□ Compared with 2002	P
2002	7	5	2.4	1830	1.0%	-	-
2003	9	9	7.9	2285	3.2%	22.97	< 0.001
2004	7	7	17.4	1721	8.9%	120.96	< 0.001
2005	8	8	17.9	2120	6.7%	83.39	< 0.001
2006	10	8	4.8	2865	1.3%	2.68	0.10
2007	9	9	8.0	2865	2.8%	18.39	< 0.001
2003-07	43	41	10.4	11473	10.4%	31.51	< 0.001

* Including only those study animals with at least 175 daily locations

Table 1. Bighorn sheep use of the restoration by year, 2002-2007, including average # daily locations in restoration area per animal, and % of locations of all animals in restoration area. Chi-square values and P values are shown for each post-treatment year (2003 – 2007) compared to the pre-treatment year (2002).

	Pre-Burn 2003-04	Post-Burn 2006-07	Chi-Square Value Pre-Burn vs. Post-Burn	P
# Locations Inside Burn Perimeter	47	8		
# Locations Outside Burn Perimeter	179	107	10.8	0.001
% Locations Inside Burn Perimeter	20.8%	7.0%		

Table 2. Comparison of pre-burn and post-burn use of the restoration area by bighorn sheep.